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Distensional Mediterranean and World Orogens

Their Possible Bearing to Mega-Dikes' Active Rising

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Extended Abstract

Introduction. Albeit the majority of the geoscience community is oriented in favour of a compressional origin of most fold belts – in full respect of the paradigm of plate tectonics – many clues can be collected that contradict this framework.

Especially significant has been the indication of the coseismic displacement of the instantaneous Earth's rotation axis in the occasion of the great Sumatran earthquake (Scalera, 2007) and Honshu earthquake, but indication that plate tectonics is a too simplistic model in disagreement with many aspects of the natural reality came from the geomorphologic studies of the great orogens, which attribute to their evolution a young age of uplifting and a preceding phase of planations that are at odds with respect to the continuous acting of the subductive process.

Seismic profiles perpendicular to the Sunda arc have not confirmed the expected nearly planar slippage surface. Also our traditional image of the Wadati-Benioff zones as plane or spoon-like patterns of hypocenters is today out-of-date after a close inspection of the 3-D large scale plots of the hypocentres locations along entire thousand-km-long Pacific active margins. Clusters and filaments of hypocenters are recognizable instead of regular patterns. These clusters taper downwards, leading to the idea of a deep origin in narrow regions of disturbance.

Besides other important facts that witness in favour of surfaceward movements of deep material coming from a key region for geodynamical researches – namely the South American Pacific margin region – additional important information came from Mediterranean area as that concerns geomorphology, earthquake hypocentral pattern, geochemistry and Paleogeography (Scalera, 2010). As consequence of all the preceding evidence, the need for a new noncollisional model for fold belt evolution become unavoidable.

The proposed noncollisional model involves global expansion, rifting, isostasy, surfaceward flow of deep material – like mega-dikes –, gravitational spreading, and mantle phase changes, overcoming the difficulties of old diapiric models. The topographic uprise of the belt can be linked to the volume increase of an isostatically uprising mantle column which segments slowly overcome a solidus-solidus boundary of the temperature-pressure phase diagram. In the depths, buoyancy forces caused by the effect of the Clapeyron phase boundary curve slope can help the uprising and out-

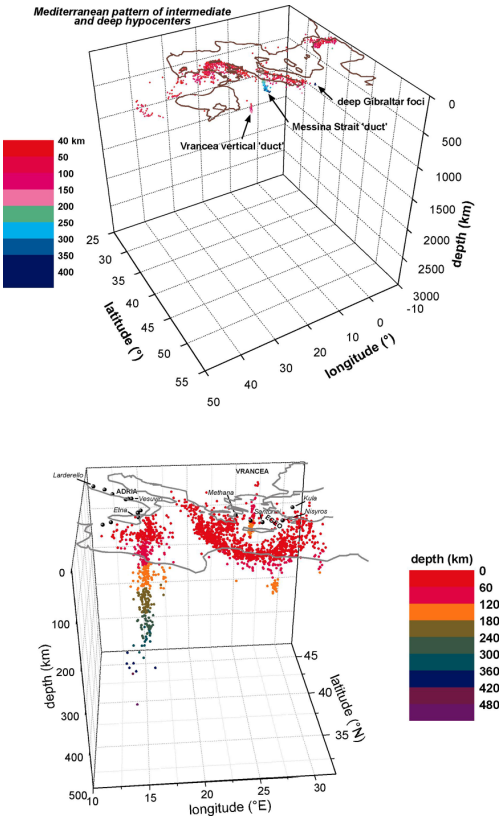

Fig. 1. a) The Mediterranean is characterised by four intermediate and deep earthquake spots: South Tyrrhenian, Aegean, West Turkey, Vrancea. Few deep hypocentres of uncertain location are present under Gibraltar. This view is from NE. b) A zoom with vertical scale exaggeration of the geographical position of the four deep foci clusters, their narrowness and azimuth are not compatible with conceivable mechanical processes linked to a very long front of subduction between Africa and Eurasia. The black circles on the surface represent the volcanoes that have erupted in historical time. Tyrrhenian foci from CSI-INGV catalogue and Aegeum and Vrancea from Engdahl Global Catalogue of relocated Hypocentres. The few low quality deep Gibraltar foci are from the USGS (2006) web catalogue extraction facility.

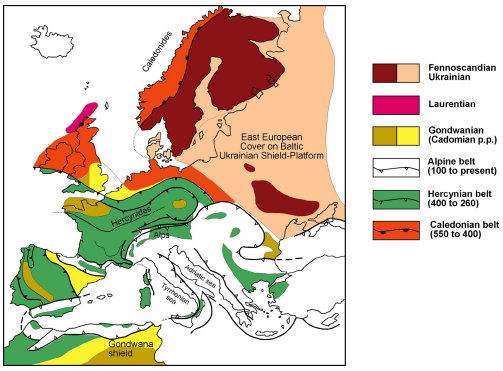

Fig. 2. Mediterranean and European geologic cycles. Like the tree rings, the old Proterozoic terranes are encircled by a series of progressively younger facies spanning from Paleozoic (Caledonian orogen, Ercynian orogen) to Mesozoic (Alpine orogens, still in act. An inspection of the map without prejudices leads to the conclusion that Africa was always slowly detaching from Eurasia and that this process has created the series of old orogens and basins progressively added to the Baltic Shield. During this slow detaching, the last phase of the Mediterranean opening is still active. In analogy to the Laurentian fragments of north England, some European Hercynian fragments are today dispersed in the Mediterranean (Sardinia and Corsica; Calabria; Kalibides on north Atlas). But also fragments of Africa (like Adriatic microplate) have been left behind during the moving away of Africa from Eurasia.

pouring process. The obtainable topographic heights are consistent with the values of volume increase that are associated to the main mineralogical phase transitions. In this view, a discontinuous upward movement of mantle materials can be linked to the observed discontinuous evolution of the orogens and to the widespread observation of uplifted coastal terraces. The model is in agreement with the P-wave and S-wave high-velocity anomalies revealed by seismic tomography under most orogens and arcs.

Overthrusts and underthrusts – of which copious geological documentation exists – should not be confused with large scale subduction. The outpouring of the material on the surface produces gravitational nappes and their overthrust on the sediments of the pre-existing trough, forcing them on a burial path which emulate the subduction process, but without reaching depths greater then 50-70 km. Phenomenon like metamorphism, mixing, migmization, upward transport of fragments

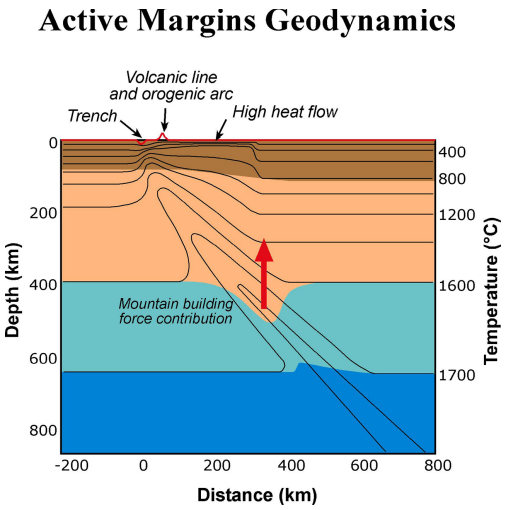

Fig. 3. The geodynamic of the new model of the active margins. The positive anomalies of seismic velocity underneath the trench-arc zones – revealed by tomographic methods – are interpreted as intrusions of isostatically surfaceward transported material (a mega-dike) which still has not changed phase. In this case the isotherms are also transported toward the surface thus locally influencing the depth to which the phase transition occurs. The effect of the Clapeyron curve slope is a protuberance of lower density material that is created in the denser transition zone. The buoyancy of this protuberance, together with the excess of volume involved in phase transitions toward less-packed lattice, contributes to the outpouring of material on the surface, namely to orogenesis. This "mountain building" force can become more efficient at the end of a spreading phase, when all the high density metastable phases are converted – also with emission of seismic energy – to more open packed lattice.

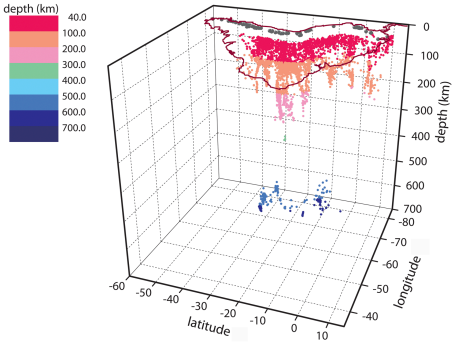

Fig. 4. The mega-dikes structure underlying South American Andean margin is revealed with the 3D plotting of the hypocentres of the new catalogue of the relocated events (Engdahl et al. 1998). Similar structures of the hypocentres distributions can be observed in a number of other orogenic belts (Japan, Sunda, Himalaya, Mediterranean ... etc.)

of the buried lithosphere etc. are possible at the boundary between uplifting material and down-pushed crust and lithosphere. The possibility that lenses-like HP-UHP exhumed fragment could be mechanical product of non-lithostatic overpressures at the same boundary and of great earthquakes occurrence at depth not exceeding few tens of kilometres should be considered.

The hydrocarbons associated to orogenic periods are scrutinized and it is found that the proposed thrust-fold belt model can better harmonize the abiogenic/biogenic processes of hydrocarbons origin. Both could be created in the dynamic forge of the thrust-fold belts evolution.

Finally, the main factor in causing the bifurcate evolution of the orogen toward either a true fold belt or in a continuously enlarging depression leading to a true marine expanding ridge and oceanic sea-floor generation could be the rate of rifting – low rate or high rate respectively – between the two lithospheric fragments. Indeed, it should be considered possible that trenches, mature thrust-fold belts and mid-oceanic ridges could be different moments or expressions of the evolution of an unique orogenic process linked to mega-dikes isostatic rising.

References

Carey, S.W. (1976). The Expanding Earth. Elsevier, Amsterdam, 488 pp.

Chopin, C. (2003). Ultrahigh-pressure metamorphism: tracing continental crust into the mantle. Earth and Planetary Science Letters, 212, 1-14.

Devoti, R., Ferraro C., Guegen, E., Lanotte R., Luceri, V., Nardi, A., Pacione, R., Rutigliano, P., Sciarretta, C. and Vespe, F.

(2002). Geodetic control on recent tectonic movements in the central Mediterranean area. Tectonophysics, 346, 151-167.

Engdahl, E.R., Van der Hilst R.D. and Buland R.P. (1998). Global teleseismic earthquake relocation with improved travel times and procedures for depth determination. Bull. Seism. Soc. Amer., 88, 722-743.

Ernst, W.G. (2001). Subduction, ultrahigh-pressure metamorphism, and regurgitation of buoyant crustal slices implications for arcs and continental growth. Physics of the Earth and Planetary Interiors, 127, 253-275.

Green, D. and Ringwood, A. (eds.) (1970). Phase Transformation & the Earth's Interior, North-Holland Publishing Company, Amsterdam, 519 pp.

Mancktelow, N.S. (1995). Nonlithostatic pressure during sediment subduction and the development and exhumation of high pressure metamorphic rocks. J. Geophys. Res., 100 (B1), 571-582.

Ollier, C.D. and Pain, C. (2000). The origin of mountains. Routledge, London, 345 pp.

Owen, H.G. (1976). Phil. Trans. R. Soc. London, Series A, 281 (1303), 223-291.

Platt, J.P. (1986). Dynamics of orogenic wedges and the uplift of high-pressure metamorphic rocks. GSA Bulletin, 97, 1037-1053.

Scalera, G. (2003). In: Scalera, G. and Jacob, K.-H. (eds.): Why expanding Earth? – A book in honour of O.C. Hilgenberg. INGV, Rome, 181-232.

Scalera, G. (2005). A new interpretation of the Mediterranean arcs: Mantle wedge intrusion instead of subduction. Boll. Soc. Geol. It., Volume Speciale, 5, 129-147.

Scalera, G. (2006). The Mediterranean as a slowly nascent ocean. In: Lavecchia G. and G. Scalera (eds.): Frontiers in Earth Sciences: New Ideas and Interpretations. Annals of Geophysics, Supplement to vol. 49 (1), 451-482.

Scalera, G. (2007a). Rend. Soc. Geol. It., Nuova Serie, 5, 214-218.

Scalera, G. (2007b). NCGT Newsletter, n.43, June, 60-68.

Scalera, G. (2007c). Geodynamics of the Wadati-Benioff zone earthquakes: The 2004 Sumatra earthquake and other great earthquakes. Geofísica Internacional, 46 (1), 19-50.

Scalera, G. (2008). Great and old earthquakes against great and old paradigms – paradoxes, historical roots, alternative answers. Advances in Geosciences, 14, 4157.

Scalera, G. (2009). Annals of Geophysics, 52 (6), 615-649.

Scalera, G. (2010a). GeoActa, Spec. Publ. n.3, 'Geology of the Adriatic area', 25-43.

Scalera, G. (2010b). La plate tectonics é una concezione "ticonica"? Giornale di Astronomia, 36 (3), 4-10.